

Developing fine-pixel CdTe detectors for the next generation of high-resolution hard x-ray telescopes

Completed Technology Project (2016 - 2017)



Project Introduction

Over the past decade, the NASA Marshall Space Flight Center (MSFC) has been improving the angular resolution of hard X-ray (HXR; $\sim 20\text{--}70$ keV) optics to the point that we now routinely manufacture optics modules with an angular resolution of 20 arcsec Half Power Diameter (HPD), almost three times the performance of NuSTAR optics (Ramsey et al. 2013; Gubarev et al. 2013a; Atkins et al. 2013). New techniques are currently being developed to provide even higher angular resolution. High angular resolution HXR optics require detectors with a large number of fine pixels in order to adequately sample the telescope point spread function (PSF) over the entire field of view. Excessively over-sampling the PSF will increase readout noise and require more processing with no appreciable increase in image quality. An appropriate level of over-sampling is to have 3 pixels within the HPD. For the HERO mirrors, where the HPD is 26 arcsec over a 6-m focal length converts to $750\text{ }\mu\text{m}$, the optimum pixel size is around $250\text{ }\mu\text{m}$. At a 10-m focal length these detectors can support a 16 arcsec HPD. Of course, the detectors must also have high efficiency in the HXR region, good energy resolution, low background, low power requirements, and low sensitivity to radiation damage (Ramsey 2001). The ability to handle high counting rates is also desirable for efficient calibration. A collaboration between Goddard Space Flight Center (GSFC), MSFC, and Rutherford Appleton Laboratory (RAL) in the UK is developing precisely such detectors under an ongoing, funded APRA program (FY2015 to FY2017). The detectors use the RAL-developed Application Specific Integrated Circuit (ASIC) dubbed HEXITEC, for High Energy X-Ray Imaging Technology. These HEXITEC ASICs can be bonded to 1- or 2- mm-thick Cadmium Telluride (CdTe) or Cadmium-Zinc-Telluride (CZT) to create a fine ($250\text{ }\mu\text{m}$ pitch) HXR detector (Jones et al. 2009; Seller et al. 2011). The objectives of this funded effort are to develop and test a HEXITEC-based detector system through the (1) design, manufacture, and test of front-end electronics instrument boards and (2) calibration of the detectors to assess their performance and (3) vibration and environmental testing. By the end of this program, multiple detector assemblies will be built and characterized, and can be used as part of future instruments. We propose to augment the existing effort with the development of an anti-coincidence shield for these HEXITEC-based detector assemblies to maximize sensitivity. Designing the anti-coincidence shield is enabled by the addition of a new team member, Wayne Baumgartner, who has recently and fortuitously joined the existing effort. Dr. Baumgartner has valuable and relevant past experience with a similar shield systems developed for NuSTAR and the InFOCUS x-ray telescope. We are asking for a modest amount of additional funding in this proposal year, as it coincides with a key time in the characterization and environmental testing of the detector assemblies. Characterization and environmental testing of the bare assemblies is already funded under the current effort. The addition of this active shield will allow for a more complete detector module vibration and environment test at the end of the existing development program so that this project results in a detector system with a demonstrated TRL of 6: "System/subsystem model



Developing fine-pixel CdTe detectors for the next generation of high-resolution hard x-ray telescopes

Table of Contents

Project Introduction	1
Organizational Responsibility	1
Primary U.S. Work Locations and Key Partners	2
Project Management	2
Technology Areas	2
Target Destination	2

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Astrophysics Research and Analysis

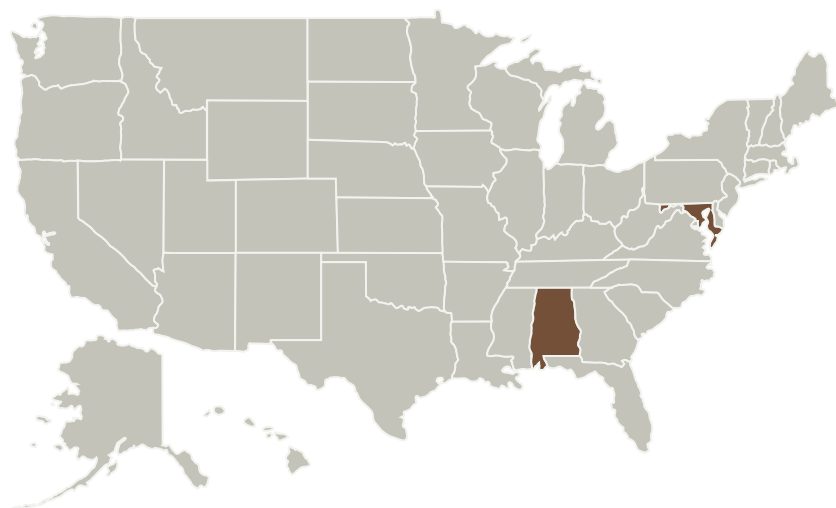
Developing fine-pixel CdTe detectors for the next generation of high-resolution hard x-ray telescopes

Completed Technology Project (2016 - 2017)



or prototype demonstration in a relevant environment. "

Primary U.S. Work Locations and Key Partners



Primary U.S. Work Locations

Alabama

Maryland

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

Steven D Christe

Co-Investigators:

Jessica A Gaskin

Wayne H Baumgartner

David T Leisawitz

Albert Y Shih

Colleen A Wilson-hodge

Technology Areas

Primary:

- TX08 Sensors and Instruments
 - └ TX08.1 Remote Sensing Instruments/Sensors
 - └ TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System